Review of the manuscript: Rüfenacht et al., "Middle-atmospheric Zonal and Meridional Wind Profiles from Polar, Tropical and Mid Latitudes with the Ground-based Microwave Doppler Wind Radiometer WIRA" submitted to Atmos. Meas. Tech.

By anonymous referee

General comment:

This paper describes updates on the wind measurement at upper stratosphere and lower mesosphere, using the improved radiometer WIRA. The authors implemented a new instrumentation of a single-side band receiver, and also introduced a new retrieval processing using the ARTS package. Comparisons with the ECMWF model are presented in order to validate the output.

The content of the paper well fits with the scope of the AMT journal, and indeed the Doppler measurement of upper atmospheric wind field is scientifically highly important. Before recommending to the publication, however, I would like to ask the authors to consider following comments. My main concern is: the lack of one reference paper which covers the same observation targets with a similar technique, and insufficient description, at least in my eyes, on the quantitative error analyses.

Specific comments:

There is one paper from satellite-based wind measurements using a submm radiometer (Baron et al., 2013). Please consider including this study as one of the references of previous studies. Note that Baron et al. also compared the difference between the observed wind and ECMWF model (which also indicated somehow large discrepancy of the measurement from ECMWF at the mesosphere compared to the stratosphere), and discussed the wind field modulation due to SSW (but of the different year); which I do believe a good and important reference for the authors' study.

…And this is just a suggestion as a possible future work: the data from the prototype WIRA with double-side band can be used for the horizontal wind (as the authors describe in the first paragraph of Sect.5). Then, it would be interesting to compare those prototype WIRA measurements in early 2010 with the SMILES wind product particularly at the mesosphere where ECMWF shows the discrepancies.

- Baron, P., et al. (2013), Observation of horizontal winds in the middle-atmosphere between 30° S and 55° N during the northern winter 2009 – 2010, ACP, 13, 6049 – 6064.

p. 7722, L 10 – 13. "*However, this information can be neglected in case of retrieving volume mixing*

profiles….(e.g., Verdes et al. 2005)."

I think whether this is negligible or not is just a matter of degree: mean, if the measurement data are with very good signal-to-noise ratio and/or if one needs very precise and accurate trace gas retrieval, then the uncertainty of the line position can also be a serious error source, I think.
Moreover, I don't see the point of putting this sentence here in this paragraph where the authors describe about the radiative transfer principle. I guess the effect of $\Delta\nu(s')$ is automatically included in the radiative transfer computation of the O3 retrieval since the authors retrieve wind and O3 simultaneously. If so, I would suggest remove this sentence.

p. 7723, L 25. *"do not directly influence the wind retrieval"*.

I do not understand the meaning of the word "*directly*" here. What can be the indirect influence? Please consider making the sentence clear.

p. 7724. L 4 – 12. "*For the ozone retrieval the values of K … profile retrievals*."

The last words "*for species profile retrievals*" are not clear. I think this paragraph describes a typical change of the observed spectrum brightness temperature, ΔTB, with respect to the variation of wind or O_3 profile. And, I think it is non-trivial to regard such ΔTB being equal to the retrieval sensitivity, as retrieval requires the information of **Sa**. Thus I do not understand why the authors can mention about "*species profile retrieval*" here. Also, the amplitude of ΔTB at one frequency alone is not enough to discuss the measurement sensitivity to physical parameters. I think ΔTB integrated over the frequency and also gradient of ΔTB in the frequency domain are also important factors when judging the measurement sensitivity… Perhaps my interpretation of this sentence is not correct, but please make it clear what the authors want to say here, and consider the improvement of statement.

Related to this statement: Please clarify the impact of error on O_3 profile retrieval on the wind retrieval. If the authors wanted to describe this with the above commented text, I would suggest the re-arrange the manuscript (as I commented above I am not sure whether ΔTB can be used for this purpose), and I would move this discussion into the error analysis part. The way how to describe such an error is up to the authors, but one possibility may be to evaluate following quantities:

$$\frac{\partial \hat{\boldsymbol{x}}_{\text{los\_wind}}}{\partial \boldsymbol{x}_{\text{O3}}}.$$

in the averaging kernel matrix.

p. 7725. Sect. 4 WIRA's retrieval setup

I think that the ARTS model can handle inhomogeneous spherical shells of the atmosphere

(i.e. capable of retrieving 3-D structures). Do the authors assume homogeneous spherical shell for the atmospheric modelling (maybe yes since the difference between east and west or north and south directions is computed afterwards)? And, it would be helpful for readers if the authors add some more description about the detailed configuration on ARTS, such as what kind of continua absorption models are used, etc.

p. 7726. L. 2, 8 "*altitude accuracy*"

I completely agree with the authors considerations for the trustable vertical range of the retrieval. However, the word *accuracy* sounds like the absolute correctness of the altitude (pressure) of the retrieved wind profile. Such a correctness cannot be discussed from averaging kernel since they provide only "relative" correctness of the altitude within the forward model. Is there any idea for re-wording?

p. 7728. Sect 4.3 *Error analysis*

This is my major concern. If I read the manuscript correctly, in this section the authors discuss the retrieval error from the measurement noise (random noise) which characterizes the "precision" of the wind retrieval. I strongly expect that the authors add further investigation about "accuracy" (bias uncertainties) of the retrieval as many other remote sensing observation publications do. Such systematic-error analysis could help us to understand possible reasons of having differences between ECMWF or other data set. Perhaps the impact of random noises would be so large that most of bias uncertainty can be negligible. Even in such a case, please confirm it in the manuscript.

p. 7728. L 20 – 21 "*As mentioned before the influence of calibration inaccuracies can be neglected for the wind retrieval…*"

Do the authors consider only frequency *independent* calibration inaccuracies, such as a constant offset over all the frequency, here? If so, how about the frequency dependent calibration inaccuracy?

p. 7729. L. 10 – 15. "*It is dependent on the noise level… on the receiver type…*"

It is not clear why the choice of single or double-side band receivers change the retrieval error. Is it just a matter of definition of noise temperature with respect to receiver type (signal-to-noise ratio of O_3 line should change between single or double side band, under the fixed noise level)? And, I am confused why the authors put the *same* noise level for single and double-side band system in order to represent typical clear and cloudy cases. Please add some more explanations why the retrieval

error depends on the receiver type.

p. 7729. L 13 – 15. "*…the error ranges from 17 to 27 m* s^{-1} *…*"

I would like to know if these error values (standard deviation of the retrieved profiles using Monte Carlo method) agree with the retrieval error (measurement error and smoothing error), which defined in Rodgers OEM, computed from the assumed measurement noise level.

p. 7732. Sect. 5.2 Comparison with ECMWF data

In the discussion about the difference between WIRA-measured wind and the ECMWF model output, do the authors take the accuracy of ECMWF into account?

p. 7732. L. 26 – 27. "*The authors do not see any reason why WIRA's zonal wind measurements should suffer from a systematical error in the mesosphere…*"

I believe that this sentence has a convincing meaning only if the authors put quantitative descriptions about the systematic-error analysis. Please consider improving the manuscript.

Figures Please try to improve the visibility of the plots: in some figures, it is difficult to read the numbers and labels of axis (particularly the superscripts of the pressure values).

Figure 9 I would change the position of the legend-box which is overlaying on the plotted profile.

Figure 11 Plotting the error profiles at both upper and lower-outside of the dashed line (trustable altitude range) as "wind observation error" is misleading. I would limit the y-axis range only at trustable vertical range.

Figure 16 x-axis label "*Relative offset…* → I would write as "*Relative difference…*

References *J. Quant. Spectrosc. Ra.* → Is this an appropriate abbreviation in AMT? Please check.